



Between a rock and a hard place: The burdens of uncontrolled fire for smallholders across the tropics



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ABSTRACT

Once fire-resistant rainforests are becoming fire prone. Uncontrolled fires reflect new ecologies of the Anthropocene, driven by interactions of multiple actors and sectors across scales. They threaten the ecological integrity of tropical forests, impact global climate regimes and importantly cause considerable social and economic burdens. Numerous smallholder farming communities throughout the forested tropics experience the immediate place-based damages of uncontrolled fires and increasingly flammable landscapes. However, these burdens remain largely 'invisible' as leading narratives concentrate on losses accrued at aggregate scales, including to climate and biodiversity. Rather, smallholder farmers are often cast as culprits of contagion rooted in colonial condemnation of their customary fire-based agricultural practices. We use an environmental justice lens, notably the dimensions of recognition and distribution, to reveal the distributional burdens of uncontrolled fires for these land managers. We use empirical data from four case studies in three countries: Brazil, Madagascar and the Philippines, to explore the i) burdens of uncontrolled fire, ii) changing risks, iii) drivers and iv) responses to uncontrolled fire, and finally, the v) level of smallholder dependence on intentional fire. We show that place-based burdens of uncontrolled landscape fire are significant, including in landscapes where fire frequency is low. Burdens are both material and non-material and include infringements on food security, health, livelihoods, social relations and the burden of prohibitive fire policy itself. Equitable responses to uncontrolled fires must be sensitive to the distinctions between fire types. Further, we suggest that through bringing visibility to the place-based burdens of uncontrolled fires, we can begin to co-design resilient responses that avoid placing the final burden of risk reduction on to marginalized smallholder farming communities.

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1. Introduction

Once fire resistant rainforests are becoming fire prone (Aragão et al., 2018). Uncontrolled tropical landscape fires are increasingly prevalent and predicted to increase in both extent and frequency, reflecting new ecologies of risk in the Anthropocene (Brando et al., 2020; Jolly et al., 2015). These uncontrolled mega-fire events threaten the ecological integrity of tropical forests (Barlow et al., 2016), impact

global climate regimes (Brando et al., 2019) and undermine the potential of environment-related interventions to secure objectives of conservation, food production and human wellbeing (Aragão et al., 2018; Barlow et al., 2012; Carmenta, Coudel, & Steward, 2018; Carmenta & Vira, 2018; Gaveau et al., 2014). Importantly, the leading discourse of tropical fire largely overlooks the considerable local burdens that uncontrolled landscape fires incur (Brondizio, de Lima, Schramski, & Adams, 2016). Although poorly quantified, these 'invisible' burdens include infringements on food security, health, livelihoods, and place-based relationships of people to landscapes (Carmenta, Vermeulen, Parry, & Barlow, 2013; Koplitz et al., 2016; Ponce Calderon, Vera Cortés, & del Álvarez Gordillo, 2020; Tan-Soo & Pattanayak, 2019). The absence of the humanitarian burden of uncontrolled fires to small-scale farmers (also referred to as smallholders

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throughout) from the leading discourse contrasts sharply with their visibility within the discourse of blame (Costa, 2006; Forsyth, 2014).

Smallholders are framed with blame embedded in negative preconceptions and derogatory views of their customary, fire-based, agricultural practices (Costa, 2006; Kull, 2004). Yet, it is simultaneously inaccurate and unjust, to attribute mega-fires to the actions of smallholder farmers, and more broadly - local land managers, alone. To the contrary, multiple stakeholders and associated fire types exist (Fearnside, 2008; Jelsma, Schoneveld, Zoomers, & van Westen, 2017; Barlow et al., 2020) and forest flammability must be considered as a consequence of the interaction of multiple actors and sectors across scales (Barlow et al., 2012; Carmenta et al., 2011; Carmenta et al., 2016; Cochran & Laurance, 2008; Jolly et al., 2015; Liu et al., 2013; Silvestrini et al., 2011). These drivers not only influence uncontrolled landscape fires through land use change and land management practices that result in forest fragmentation and degradation, but through influencing global environmental change itself (Bonan, 2008; Lawrence & Vandecar, 2014; Withey et al., 2018). Nevertheless, the tropical mega-fires of recent years, such as those seen in the Brazilian Amazon and Indonesian peatlands, continue to cast smallholder farmers as considerable culprits of fire contagion (Carmenta, Zabala, Daeli, & Phelps, 2017; Porter-Jacobs & Carmenta, 2017), at times as a tool of political misdirection from more controversial causes of fires (Varkkey, 2016). This is despite the fact that while the occurrence of uncontrolled mega-fires is increasing across the tropics, the number of swidden farmers globally is in decline (Dressler et al., 2017; van Vliet et al., 2012).

Swidden agriculture has enabled autonomous and intergenerational food security in contexts associated with rich biocultural diversity (the biological and cultural diversity of a place), peripheral to state-support and characterized by limited access (Dressler et al., 2017; Maffi & Woodley, 2012; Padoch & Pinedo-Vasquez, 2010). Despite the utility of intentional fire and the contribution of swidden to local and regional food security, cultural identities and agro-diversity, the practice is condemned partly because swidden fire (i.e. intentional agricultural fire) and uncontrolled mega-fires (i.e. fires of multiple origin and intent including escaped intentional fires) are conflated (Barlow et al., 2020; Carmenta, Vermeulen, Parry, & Barlow, 2013). For those smallholders who are reliant on fire, or farming in fire-prone landscapes, the contemporary and increasing risks of landscape flammability thus likely pose considerable challenges and raise important issues associated with environmental justice.

We use the lens of environmental justice to frame our analysis and highlight the failures of the leading fire narrative to recognize distinctions between the intentional swidden fire of smallholders and uncontrolled tropical fires, and consider the distributional burdens of impacts from, and responses to, uncontrolled landscape fires for smallholders. We focus on empirical data that raises the visibility of the lived burden of uncontrolled fire for smallholder farmers and juxtapose the risk and reality of uncontrolled fire with fire dependence in four distinct contexts. These case studies offer pan-tropical vignettes of the fire context and are drawn from i) riverine communities along the Arapiúns river, Pará, Brazilian Amazon; ii) colonist and riverine farmers of the post-agricultural frontier in Paragominas and the neighbouring municipalities, Pará, Brazilian Amazon; iii) smallholder farmers on the humid eastern escarpment of north-eastern Madagascar and iv) the Palawan region of the south-western Philippines.

2. Environmental justice and the leading discourse on tropical fire

Environmental justice has three main dimensions, a distributive dimension that is concerned with the equity in the distribution of

environmental benefits and burdens. A dimension that considers the justice of recognition, including recognition of the communities affected by environmental policy and environmental change, and recognition of the plurality of impacts across different socio-natures and values. And lastly, a procedural dimension which considers the equity and inclusion of affected peoples in decision-making processes related to environmental policy (Martin et al., 2016; Schlosberg, 2004, 2009). These dimensions have been used to engage moral principles and in turn make normative claims about the prevalence and reasons behind levels of just and unjust distributions of environmental change. Although environmental justice has been applied as a lens through which we can better understand the distribution of environmental harms, for example in the context of hazardous waste (Martinez-Alier, 2001), it has not been explicitly applied to the context of tropical fire. In this paper, we focus on the dimensions of distribution and recognition in approaching the leading fire narrative and framing our empirical findings.

2.1. Recognition

Taking recognition as a starting point, the leading approach to fire in the tropics persistently undervalues, disregards and fails to recognize the local utility of fire, by prohibiting it (Carmenta, Vermeulen, Parry, & Barlow, 2013), or by taking a *laissez-faire* approach which essentially ignores the need for support to enable a more safe and sustainable use of fire in the face of increased landscape flammability (Cammelli & Angelsen, 2019; Carmenta et al., 2013; Sorrensen, 2009; Varkkey, 2016). The roots of the leading prohibitive fire discourse are grounded in the colonial era and the legacy remains visible today (German, 2010; Kull & Laris, 2009). Yet fire is essential to local food security, central to biocultural diversity, inherent in cultural identities and has enabled the persistence and resistance of traditional smallholder communities across the global south (Kull, 2004; Carmenta et al., 2013; Maffi & Woodley, 2012; Padoch & Pinedo-Vasquez, 2010; van Vliet et al., 2012; Nazarea, Rhoades, & Andrews-Swann, 2013). In some instances techniques such as intercropping with nitrogen fixing plants (e.g. Inga) has enabled customary agriculture to be adapted towards fire-free practices (Barber, 2009). The state has tended to favour and incentivize larger-scale, sedentary and often monocultures of agricultural enterprise and supported 'induced innovation' towards intensified agriculture (Dawson, Martin, & Sikor, 2016), or engaged in transmigration to move farmers away from swidden practices (Fox et al., 2009). The needs and representation of smallholder farmers are typically absent from the policy process (Cammelli et al., 2019; Carmenta et al., 2013; Viana et al., 2016).

Further, the semantics of the leading fire narrative - and associated policy responses, fail to distinguish between intentional agricultural fire and uncontrolled fires, much less the various types of fire, rather situating all fire within a single category of 'undesirable'. Yet, fire types are distinct with particular causes and consequences, flows of benefits and burdens, preferences and incentives for control and management (Barlow, Berenguer, Carmenta, & França, 2020; Bowman, Amacher, & Merry, 2008; Cammelli & Angelsen, 2019; Carmenta et al., 2017; Dennis et al., 2005; Kull, 2004; Purnomo et al., 2017). Further, a multiplicity of local actors, including new arrivals and absentee land-holders, are today using (or contracting) fire in forest frontiers (Barlow et al., 2012; Gaveau et al., 2017; Jelsma et al., 2017). This complexity is often reduced to leading narratives of nefarious fire within which smallholder farmers are ascribed attribution (Smith & Dressler, 2020; Costa, 2006; German, 2010; Kull, 2004; Porter-Jacobs & Carmenta, 2017), and ignoring the multiplicity of drivers and liabilities underlying escaped fires (Barlow et al., 2020; Cattau et al., 2016; Gaveau et al., 2017).

Often burning is prohibited unless practiced following legal and policy prescriptions, many of which do not recognize local realities and instead are misaligned in terms of local technologies, labour requirements, conceptions of fire and customary management practices (Brockhaus, Di Gregorio, & Carmenta, 2014; Eloy, Bilbao, Mistry, & Schmidt, 2019; Sletto & Rodriguez, 2013). There are some contemporary exemptions from fire bans for smallholder farmers (e.g. in Indonesia (Daeli, Carmenta, Monroe, & Adams, forthcoming), in Brazil (Eloy et al., 2019), yet they often fail to address smallholders' needs for a safe and sustainable fire use in the face of increasing landscape flammability and climate change, and can lead to detrimental social and environmental outcomes (Cammelli, Garrett, Barlow, & Parry, 2020). The prohibitive, and the *laissez-faire* approaches represent burdens themselves and have the potential to backfire by creating increasingly illicit burning conditions, and preventing a narrative towards equitable action (Carmenta et al., 2018; Kull, 2002).

2.2. Distribution

A significant shortfall of the dominant fire discourse concerns the distribution of the benefits and burdens of distinct fire types (i.e. intentional and accidental). This concerns in particular the centrality of intentional (agricultural) fire to smallholders on one hand, and the lived experience of uncontrolled fire on the other. Further, the leading fire discourse and much of the (largely natural) science exploring the burdens of fire tend to highlight those external losses generated at aggregate scales, for example the burdens accrued to biodiversity, climate change and to the economy (Aragão et al., 2018; Campanharo, Lopes, Anderson, da Silva, & Aragão, 2019; Cochrane, 2003; de Oliveira et al., 2019; Streets, Yarber, Woo, & Carmichael, 2003). These high-profile accounts of the aggregate remote burdens of uncontrolled fires, stand in contrast to the scant recognition of the place-based burden incurred by smallholders (Brondízio et al., 2016). The place-based impacts of uncontrolled fire have been poorly documented, but include damage to material assets and reduced income (Cammelli, Coudel, & Alves, 2019), degraded forest resources (Barlow et al., 2016), the burden of prohibitive fire policy (Carmenta et al., 2018; Kull, 2002; Thung, 2018), and grave health implications of prolonged smoke exposure (Brondízio et al., 2016; Koplitz et al., 2016; Nawaz & Henze, 2020; Reddington et al., 2015; Tan-Soo & Pattanayak, 2019). At the same time, intentional fire derives benefits for many types of actors and land managers (Barlow et al., 2020; Carmenta et al., 2017; Purnomo et al., 2017). For smallholders of the global south in particular, fire-based agriculture enables autonomous production to meet subsistence needs, supplemented with fishing, forest extraction and sale of modest surplus to local markets (Dressler et al., 2017; van Vliet et al., 2012). The enabling role of intentional fire is omitted from leading fire discourses and related policies. Thus the distribution of benefits and burdens of fire preventative policies, landscape flammability and intentional fire are unevenly distributed between citizens.

Sustainably and equitably governing transboundary environmental problems is a significant challenge, yet panacea policy responses informed by misrepresentative semantics can be damaging and incur distributive burdens that extenuate the vulnerabilities of already marginalized groups (Carmenta et al., 2018; Friess, Phelps, Garmendia, & Gómez-Baggethun, 2015; Harwell, 2000; Thung, 2018). For example, the blanket ban of all fire that occurred following the extensive peatfires in Indonesia unduly impacted swidden farmers on mineral soils – i.e. land managers that were not associated with the oil palm expansion in peatland frontiers (Thung, 2018). Further, recent research has shown how preventative fire policy in conservation units can increase the risk of fire escape through increasing secrecy and illicit conditions around

burning (Carmenta et al., 2018), or favouring fire-prone invasive species (Rai, Benjaminsen, Krishnan, & Madegowda, 2019), thus jeopardizing local residents with perverse policy outcomes. Such findings point to the potential of recognition to inform procedural justice through more equitable policy measures.

The long-standing prohibitive approach to burning in the tropics carries a distributive dimension – it fails to adequately distribute policy measures across the stakeholders driving fire prevalence. Such a distribution would necessarily involve measures targeted to the multiple land user groups influencing land management, and acknowledge the broader political economy and distant connections (e.g. remote consumer preferences) contributing to landscape flammability (Barlow et al., 2018; Corbera, Busck-Lumholt, Mempel, & Rodríguez-Labajos, 2019; Sorrensen, 2003).

3. Case study contexts and data collection

In this paper we present data obtained through multiple methods in four case studies that included quantitative and qualitative field methods (e.g. questionnaires, interviews, participant observation) and policy review (Table 1). Research efforts were not coordinated *a priori* but each study was motivated by an interest in understanding human-fire interaction, particularly the local burdens of uncontrolled fire, the degree of fire dependence, and the contested nature of fire governance at the forest frontier. Thus together the data created the possibility for *post-hoc* collective (not comparative) analysis and a pan-tropical snap-shot of smallholder realities in the context of fire.

The case studies afford a grounded appraisal of living with fire in a context of increasing landscape flammability. Each case study has in common some degree of experience of uncontrolled fire, forest use and extraction, and dependence on smallholder agriculture on mineral soils, where fire is, or has been until recent years, the mainstay of local food security. In all sites fire is criminalized by the State if used outside of dictated parameters, however in reality fire is used on a daily basis and reflects the notion of everyday incremental resistance (Kull, 2002; Thung, 2018). While these similarities exist, the cases capture unique contexts including their type of market access, degree of market integration, alternatives to fire-based agriculture, degree of forest dependence, and the level of sanction and enforcement of fire policy. While the cases are not comparative in design, they afford rich insights in to the local burden of uncontrolled fire in different contexts and offer grounded vignettes of the impacts of landscape flammability in fire dependent communities. The case study contexts are described below and key features summarized in Table 2.

3.1. Brazil

3.1.1. Arapíuns, Brazil

The field research in the Arapíuns site took place along the Arapíuns river, a first order tributary of the lower Tapajós river in Pará state, Brazil. Research was conducted between June and December 2011, within 12 *ribeirinho* communities now encompassed within two extractive reserves. Brazil's *ribeirinhos* are heterogeneous historical peasantries with indigenous and European forefathers and north-easterners of African origin (Filho, 2009; Harris, 2000). They emerged from the detribalization of native populations following European arrival in the Amazon (Parker, 1989). Although often ignored by anthropologists and sociologists alike (Nugent, 2005) *ribeirinhos* are one of the most numerous rural people in the Brazilian Amazon, and are often on the periphery of Brazilian society (Adams, Murrieta, Neves, & Harris, 2010). They draw heavily on indigenous modes of existence, living by subsistence-oriented

Table 1

Case study community attributes. Distinctions between the four case studies in relation to Fire and Forests and Farms and Markets. These descriptives refer to the case study communities specifically and not to the regions at large.

Case study communities				
	Paragominas, Brazil	Arapiruns, Brazil	Maroantsetra, Madagascar	Palawan, Philippines
<i>Fire and forests</i>				
History of fire escape	High.	Moderate ¹ . 1998, 2006 and 2015 mega-fire events.	Low.	Low.
Forest fragmentation and extent of additional land uses	High. Landscape is occupied by pasture and forest in fragments.	Low. Communities practice swidden within a reserve. Large extents of forest, although logged.	Moderate. Landscape is occupied with large continuous forest areas surrounded by agroforestry plots, rice fields, and forest in fragments.	Moderate. Landscape is occupied with swidden and agroforestry plots, rice fields, and forest in fragments, some (>500 m asl) of which is protected.
<i>Farms and markets</i>				
Average plot size (ha)	47	2	1	0.251.0
Transition to fire-free agriculture	Low-Moderate. Scarce or no extension in <i>ribeirinho</i> communities. Some perennials and intercropping in land reform settlements. Some light tractors available. Most cattle ranchers adopt manual pasture maintenance.	Low. Kitchen gardens and perennials in agroforests are used but agriculture is fire-based with manual labour, no extension for fire free and inputs are rare.	Moderate-High. Many farmers have established irrigated paddy rice fields and agroforestry plots and now buy subsistence items with cash crop income.	Low Moderate. Farmers have established swidden and agroforestry systems.
Market integration	Moderate. Crops mostly sold through middle-men. Output markets include the Brazilian program for rural school meals, local and regional markets. Subsistence production is higher among <i>ribeirinhos</i> .	Minimal to Moderate. Most crops produced for household consumption, surplus sold to local market.	High. Cash crops sold to international markets through middle-men.	Minimal to Moderate. Mixed cropping system involving subsistence and cash crops. Most crops produced for household consumption, surplus sold to local market

¹ The data presented in this study are from 2011, preceding the 2015 fire event in the region.

Table 2

Collective set of methods. Summary of the different field research methods and respective dates of data collection in the four case study sites.

Case study	Household questionnaire	Structured interview	Participant observation	Focus group discussions
Paragominas, Brazil	207	–	–	–
Santarém, Brazil	154	4	6 months	4
Maroantsetra, Madagascar	–	49	–	2
Palawan, Philippines	–	20	14 months	–

swidden agriculture, fishing and forest extraction with surplus sold in local markets (Adams et al., 2010; Fraser, 2010; Murrieta & WinklerPrins, 2003). An increasing role of State-sourced benefits and salaries constitute increased off-farm income (Adams et al., 2010). Extensive areas within each of the reserves burnt in 1998 and large scale wildfires passed through the region again in 2015 and 2017 (Withey et al., 2018). In 2015 these large-scale fires impacted 7400 km² – an area that exceeded the total area deforested in the entire Brazilian Amazon during the same year (Berenguer et al., 2016).

3.1.2. The Paragominas region, Brazil

Field research in the Paragominas case study took place in two *ribeirinho* communities and 15 agrarian reform settlements (*colonos*) in October to December 2015. Respondents were from small-scale farming households (<55 ha and 56 to 220 ha)¹ as classified by the Brazilian agricultural agency (INCRA). Paragominas is a post-frontier region in the Brazilian Amazon and a relatively new municipality (founded in 1965) situated along the Belem-Brasilia highway. The region is a highly fragmented forest landscape with a considerable history of extensive fires (Hasan, Laurent, Messner, Bourgoin, & Blanc, 2019). The landscape is dominated by pastures,

large landholders and hosts a predominantly urban population (Viana et al., 2016). Its deforestation-based economy of large-scale cattle ranching, soy, and timber extraction led to a 44% drop in forest cover since its foundation (Ibid.). Yet, after being blacklisted and targeted by federal anti-deforestation policies, the municipality shifted towards an ambitious Green Municipality program, which included a ban of all fires in forest areas (Art 97. Municipal Law 765, 2011), but allows controlled agricultural management fires upon licensing, in line with federal legislation (Brazilian Forest Code, 2012, 1965). Yet until 2016 fire licensing was only issued by state authorities in the capital city of Belém, an unaffordable travel for many smallholders, forced into illegality. Transitions from fire based land management have taken place for some actors in the region but many smallholder farmers depend on fire for production.

3.2. Maroantsetra, Madagascar

Field research in Madagascar took place in July and August 2018, in two communities, located at the eastern forest frontier in the humid and hilly Maroantsetra district. This area contains the largest remaining rainforests in Madagascar, and has therefore attracted conservation efforts at the same time as illegal timber exploitation to satisfy Chinese rosewood demand (Zhu, 2017). Both communities are in buffer zones of protected areas (Makira Natural Park and Masoala National Park), and are engaged in production and export of high-value cash crops- vanilla and clove. Fire-based swidden cultivation for subsistence rice production has long been practiced but smallholder dependence on swidden is decreasing.

¹ These landholdings (known as 'micro' (<55 ha) and 'smallholder' (56–220 ha) appear disproportionately large compared to those in the other study areas, however landholdings are dominated by extensive cattle ranching and are required to preserve up to 80% of land as 'forest reserve' see <http://www.incra.gov.br/tamanho-propriedades-rurais>.

The dramatic increase in the value of vanilla on the international market helps to explain the vanilla expansion in the region (since 2013). Restrictions on land access associated with the protected areas has shortened shifting cultivation cycles, reducing nutrient levels and leading to decreased rice yields (Liopis et al., [accepted](#)). The increased incomes from export crops, combined with soil degradation and land access restrictions has meant more households are converting part of their fallows into agroforestry plantations for cash crops. The island has a long history of fire politics with periods of fluctuating intensity of fire suppression that began in the pre-colonial period (Kull, 2004, p. 206), although the case study area has not experienced major accidental fires. Today, national law forbids to burn any forests. However, for the case of burning to establish shifting cultivation on existing fallows, farmers can obtain authorization from the local state administration.

3.3. Palawan, Philippines

Field research in the Philippines took place between March and April in 2004–2011 and 2017 within 4 communities in the buffer zones of Puerto Princesa Subterranean River National Park and Mount Matalingahan Protected Landscape in central and southern Palawan Island, respectively. Indigenous Tagbanua and Pala'wan smallholders have complex livelihood portfolios, which combine swidden with agroforestry, non-timber forest products (NTFPs) collection, coastal-marine harvests, as well as off and on-farm labour (Fabinyi, Dressler, & Pido, 2017). Increasingly, these groups rely on the cash incomes derived from cash crop production (e.g., rubber, oil palm), daily labour and credit, (over)exploiting NTFPs and the reef fish food trade (Dressler & Fabinyi, 2011; Montefrio & Dressler, 2018). Despite these livelihood changes, the majority of indigenous farmers predominantly depend on swidden for subsistence and cash by selling surplus to local markets.

In much of Palawan, multilateral institutions, state agencies and NGOs have designed protected areas and community-based programs reinforcing swidden farmers' broader shift to sedentary agriculture while clarifying responsibilities to manage fire or simply not to burn (Dressler, 2014). Promoting Palawan as a major 'ecotourism' destination, the then Mayor established a 'Zero-burning' Ordinance in 1994. Farmer protest and petitioning from indigenous NGOs led to a revision and a 'Controlled Burning' Ordinance (No. 110-94). More recently, the Municipality of Brooke's Point in southern Palawan also proposed a Zero Burning Ordinance, which, after a series of NGO protests, was eventually overturned in favour of 'controlled burning' (Dressler, 2015). The area does not have a history of extensive uncontrolled fires, though Tagbanua and Pala'wan swidden farmers have been subject to intensifying anti-fire policies and practices through proximity to the national parks, and the expansion of biofuel plantations in the region. Indeed, despite major legislative reforms recognizing indigenous peoples rights to land (e.g. IPRA, 1997) and endorsing community-based initiatives to land management (e.g. NIPAS, 1992), the status-quo of regulating against swidden and fire has remained in place (e.g. see the Community-based Forest Management (CBFM) initiative of 1995). Forest governance initiatives, environmental programs and corporations now all advocate for market-based schemes and incentives to facilitate 'added value' agriculture to curb swidden and the use of fire.

4. Emergent themes from distinct fire contexts

We organize the results around five themes that emerged through the case studies. The themes span the i) burdens of uncontrolled fire, ii) changing risks, iii) drivers and iv) responses to uncontrolled fire, and finally, the v) level of smallholder depen-

dence on intentional fire. Insights from each case study are presented within the themes, and the dialogue with environmental justice considered in the discussion.

4.1. Recognition of the place-based burdens of uncontrolled fires for smallholders

Losses from uncontrolled fires were documented in each of the case studies and included material goods and resources, as well as non-material costs such as lost opportunities, and relational burdens.

4.1.1. Material burdens

Material losses included damages to crops, to infrastructure and to the forest resources that smallholders integrate in their livelihood portfolios. In the Arapiúns, many of the farmers that experienced fires lost perennial and agroforestry plots and annual subsistence crops. In some instances durable goods and assets (including houses and agricultural outbuildings) were also lost to fire. In the Paragominas case study, farmers reported considerable damages up to values of R\$ 80,000 (relative to the minimum monthly wage of R\$ 788) and were accrued through damages to pasture fences, infrastructure (including homes and agricultural work-houses), perennials and pastures (i.e. where the cost of lost pasture was associated with the cost of renting alternative pasture).

Forest degradation from fire created burdens in each of the Brazilian case studies. Over half of the households spoke about lost access to unburnt forests. Farmers reported that fires negatively impact almost all NTFP species (including nuts, fruits, vines) and timber species that are important in local livelihoods. In both sites, farmers spoke of the difficulties of utilizing burnt forests in traditional ways, because they become impenetrable and dominated by 'dirty' undergrowth. For example, daily activities such as fuelwood collection was considered more dangerous because dead trees were unstable and because of a perceived increase in snake densities following forest fires. Snakes are thought to be attracted by the increased abundance of rodents and the availability of niches for concealment provided by the debris. Hunting was made more difficult because the dry debris and dense undergrowth prevents silent passage through the forest, and because many species populations fall following fires. People reported the burden of increased travel times to access unburnt forests, yet chose to do so because of better hunting and extraction conditions.

Smallholders in the Malagasy case study spoke of their experience of damages from uncontrolled fire in their clove, vanilla and coffee plantations, including rare events of complete lost yield. The main burden was a decrease in cash-crop yields and presented a long term burden to farmers. Other material impacts reported by single respondents in Madagascar included that they suffered economically due to the costs of replacing clove and vanilla plants, that life in general became more difficult due to the foregone income opportunity, lost subsistence crop production (i.e. hill rice fields or litchi trees) or lost forest, and fallow vegetation (and their products). Nevertheless, some respondents felt that the economic impact from the uncontrolled fires was low because cash crop prices were low at the time.

The Palawan case had least direct material losses from uncontrolled fires. However, there was an economic burden to smallholder farmers created from the prevailing anti-fire position in the region. Households had been subject to sanctions and punitive actions including fines, and anti-swidden and anti-fire campaigns. Further, farmers tended to follow the anti-fire stricture, and without properly burning, went hungry after failing to produce a sufficient rice harvest.

4.1.2. Non-material burdens

Non-material burdens of uncontrolled fires included a number of relational and well-being impacts, including the burden of anxiety related to anticipating uncontrolled fires, curtailed decision-making in crop choices, fear for personal and family safety, health concerns, social sanctions and the anguish of prohibitive policy.

The burden of anxiety and risk perception related to uncontrolled fires was highest in the cases exposed to higher frequencies of uncontrolled fires (i.e. in the Brazilian sites). In the Arapíuns, around half of the smallholder households believed that their land and property suffered from a definite, probable or possible risk of uncontrolled fire. In Paragominas, most people perceived that their and their neighbours land and property suffered from a risk of uncontrolled fire. These concerns of fire invading the landscape meant that smallholders in the Paragominas and the Arapíuns case studies were unable to practice their autonomy over crop choices, for example they were curtailed from investing in perennials because of the risk of losing investments. In Paragominas, the lack of a municipal licensing system marginalized smallholder identities by focusing on the illegality of fire and provision of extension services to facilitate the adoption of fire-free techniques was severely limited. Similarly in the Arapíuns, the notion that plot sizes were being invigilated by the reserve management authorities, and fire practices subsumed within that, households were aware that their autonomy over land use decisions was being weakened through the management structures of the reserve.

Other non-material burdens stemmed from the practice of fire-fighting to control accidental fires. In Paragominas respondents recalled fire-fighting as a highly challenging, dangerous activity and reported traumas such as intoxication, eye infections, and a general heightened fear of fire. Uncontrolled fire was associated with social conflicts and lower quality neighbourhood relations in the Paragominas case, and in the Arapíuns there was a level of disappointment in the quality of land management being practiced at the community level that eroded community pride and concern that the intergenerational flow of fire knowledge, and thereby smallholder identities derived through swidden, was being lost as younger people were influenced by the presiding stigma of fire and some showed disdain for traditional land management practices.

In the Palawan case study the anti-fire position of key stakeholders has placed a very real burden of responsibility on smallholders and instilled a lasting and pervasive fear of burning amongst many smallholders. These anxieties were extenuated though the lived experience of climatic anomalies and of the continued necessity to burn in such conditions, particularly during extreme years (e.g. El Niño events).

In the Madagascar case study, the process of restricting fire-based land management has itself contributed to extenuating the vulnerabilities of the most marginalized groups. Notably, those without access to clove or vanilla start-up costs faced both higher prices for their consumables due to the vanilla boom and its impact on the local economy, and an environment in which the burning necessary to their agricultural production was increasingly prohibited – through the state law, the national park and related NGO activity, but also by social sanctions from clove and vanilla farmers. The expansion of lucrative cash crops in the area has been associated with a fall in fire use on one hand, but with the erosion of social fabric, as harvesting swidden plots was a social activity and as valuable cash crop harvests are sometimes stolen by competitors, on the other.

4.2. The frequency and changing nature of the risk of uncontrolled fires

Living with uncontrolled fire was the reality in all of the case study sites and smallholders in every case had experiences of such

events. The history of fire escape (i.e. fires escaping from owners plots) and uncontrolled fire (i.e. uncontrolled fires moving through the landscape without knowing the source) was highest in the two Brazilian cases. In the Arapíuns, nearly half of the households had experienced accidental fire on their land, mostly fires that reportedly began as intentional fires in land managed by neighbours. In the Paragominas case study, around half of interviewed farmers experienced damages from accidental fires *at least* once in the previous five years, and some of those experienced more than one. In total, 169 uncontrolled fires were recorded by 109 households over 5 years. Uncontrolled fires reportedly tended to originate from neighbours' land, or were related to larger conflagrations starting in unknown places.

The Madagascar and Philippine case studies had a lower frequency of past uncontrolled fire events. In the Palawan case – only a few households had experienced uncontrolled fires, and these were exclusively accidental fires that escaped from their own plots. In Madagascar, more smallholders reported that they had been affected by uncontrolled fires, at least once, and some twice.

In regard to changing fire risk over time, local understandings of the degree of risk exposure was contested within sites. In the Arapíuns site, around half of the households perceived that the risk of uncontrolled fire had fallen over the last 20 years, yet a quarter of households perceived the risk has increased, while some perceived no change. In Paragominas, perceptions of changes in fire risk were also variable: split largely between households believing that fire risk was increasing, those that believed it was decreasing.

In the Philippine case study, fire escape was relatively uncommon, yet all smallholders were concerned about the risk of escape fire and there was a general sentiment that the risk was increasing. In Madagascar, almost all respondents perceived that the risk of fire escape had fallen over time and most people were not concerned about the risk of fire escape, only a few households perceived a high risk and most perceived a medium–low risk of uncontrolled fire. The decrease in fire risk in the Malagasy case was perceived to be associated with the establishment of the protected areas. Decrease in fire risk was also attributed to the sensitization activities by the protected area agents and authorities and the fear of sanction from strict control by protected area personnel. The transition of shifting cultivation systems to agroforestry was another reason for the decrease of uncontrolled fire, both because it reduced the need for fire-based land clearance and because farmers avoided fire in order to protect the cash. There was a perception that people today were more careful when using fire and followed the rules.

4.3. Smallholder perceptions of the drivers of uncontrolled fires

Smallholders in each of the case study contexts perceived the multi-dimensional and cross-scale drivers of fire, from climatic factors and ecological attributes of the landscape, to governance structures and interventions, and the individual behaviours of land and fire managers.

In the Paragominas region prolonged dry seasons, logging, prevalence of invasive species of flammable grasses (e.g. capim furão – *Panicum aquaticum*), and pasture-dominated landscapes were all considered important factors. Individual behaviours played a role and included fire management practices, careless cooking fires lit by hunters, throwing cigarette stubs, and burning rubbish. Abandonment of agricultural lots in agrarian reform settlements were perceived to have increased fuel loads and led to an increase of squatters who in turn were less careful using fire. Community factors such as a lack of integrity, coordination and communication with neighbours were also often reported as indirect drivers of uncontrolled fires. Further, in Paragominas, smallholders suggested that the absence of compensation mechanisms

for damages from accidental fires created a negative cycle in which rather than coordinate for fire risk mitigation, farmers considered reciprocal fire carelessness was justified given accidents in the previous years.

Climatic stressors were mentioned in the Arapíuns, Paragominas and Palawan case study sites. In Paragominas, prolonged dry seasons, wind, combined with hot weather and prolonged drought were perceived to reduce the effectiveness of all local fire control measures. In the Arapíuns case climate stressors, forest degradation (including from past fires) and the number of people using fire (i.e. population increase) were regarded as contributing to the susceptibility of the landscape to uncontrolled fires.

Factors across scales were also cited in the Malagasy case study including environmental factors such as strong winds, and individual behaviours such as a lack of people supervising intentional fires, and the absence of firebreaks or inadequate firebreaks.

4.4. Responding to and recovering from uncontrolled fire

In the absence of state support, controlling, containing and recovering from uncontrolled fire was left to the farmers alone and fire risk reduction was most commonly practiced through work-groups.

Only in the Paragominas sites was federal-intervention for fire control reported (by the Federal Environmental Agency (IBAMA, PREVFOGO) and it was occasional. To combat fires in Paragominas, farmers usually attempted to divert the fire towards a creek or a dense forest where it is easier to control. In the Arapíuns, smallholders attempted to contain escaped fires by relying on the labour of family and community members to contribute to containing the fire. They tended to make firebreaks and carry water to douse the flames, and some households wet their houses for protection. In the Arapíuns, local fire management was regarded as a key factor contributing to reducing fire escape and local fire management practices were regarded as central to determining levels of fire risk over the last 20 years. Sanctions, trainings and a reduction in fire use were additional factors perceived to reduce the risk of fire escape in the region.

In Madagascar, smallholders fought uncontrolled fires in collective groups and centred efforts on protecting crops rather than houses, yet often smallholders affected by accidental fire were unable to react since they were unaware of the event until it was too late. Community sanctions in response to uncontrolled fire included issuing warnings to the owner of the escaped fire, counting the burned plots, gathering the larger family (lineage) and implementing a rule among the descendants to avoid repeat occurrence, or to find an agreement with the support of the customary authorities, "tangalamena".

Recovery responses were variable in the different case studies. In the Philippine case calamity rice was issued by the state to compensate for insufficient rice harvests due to fire bans. Yet compensation mechanisms were mostly non-existent in instances involving recovery from fire damages. This fell upon smallholders alone. Even with the calamity rice, many smallholders turned to forage for wild root crops (e.g., *Korot Dioscorea hispida*) to supplement diets due to rice crop failures and would support one another (e.g., *Bayanihan*) when recovering from an uncontrolled fire.

In the Arapíuns, most households did not have a predetermined strategy to overcome their losses, others replanted their crops, constrained household spending or even migrated. Social norms of reciprocity and exchange enabled households to support one another in kind. In Madagascar, only one of the affected respondents who lost crops received a compensation in the form of labour. For those who didn't receive compensation, most said that social relations or family relations in the village were more important, and farmers replanted the burnt parts of their plots them-

selves. The escaped fires did not lead to any problems with authorities, as people didn't report the fires because either the issue was resolved within or among families, or they wanted to avoid problems with social relations in the village.

4.5. Smallholders still depend on intentional fire

Despite the significant burdens of unintentional fire for smallholders, the changing risks associated with traditional fire management practices, and the stigma of fire and peril of associated sanctions, many smallholders in all case studies continue to depend on intentional fire. Intentional fire had a central role in smallholder food security in each of the case study sites. Reliance on fire-based agriculture was highest in the Philippine case study, where all smallholders used fire to develop their swidden plots and in the Arapíuns. In the Madagascar and Paragominas sites transitions from fire-based agriculture were evident and fire dependence was lower but still engaged over half of the population.

For most fire-dependent households alternatives to fire-based farming were not available. In Paragominas, some farmers used machinery (i.e., tractor), inputs (i.e. fertilizers) or new techniques (i.e. manual mulching), however, overall many farmers stated they would be unable to produce without fire, even in the case of a fire ban. In Madagascar, for those households that were still using shifting cultivation today, nearly all said if they had to give up shifting cultivation, they would be in great difficulty to obtain enough rice to eat.

In the Arapíuns also, most households stated that they did not know of a usable *and* available alternative to fire for agriculture. The most commonly cited alternatives were direct planting, mechanization, agroforestry and perennial production and timber harvesting. Of these, only perennial production was in use since resources for mechanization and direct planting (i.e. without burning) were not available. In the Philippine sites also, capital-poor smallholder farmers considered there was no accessible fire-free alternatives.

In all case studies smallholders recognized drivers across scales, yet in all cases the burden of fire management within fields was born by smallholders alone. Drawing on manual labour and hand-tools and following ecological and climatic cues to contain their agricultural burns using a range of fire control measures or to combat uncontrolled fires when necessary.

5. Discussion

5.1. Smallholders between a rock and a hard place

Contemporary smallholder farmers are living through changing contexts in terms of fire risk and fire prevalence, driven by factors across scales and yet resulting in immediate local burdens. On the other hand, smallholder farmers are subject to a leading narrative of tropical fire that renders the place-based burdens invisible, the local necessity of intentional fire unrecognized and support for reducing fire risk unavailable. Meanwhile smallholders must manage uncontrolled fires and recovery from associated burdens. We conceptualize this through the metaphor of a rock- the policy environment and invisibility of smallholder realities, and a hard place- new and riskier contexts of fire-based agriculture in the Anthropocene (Fig. 1).

5.2. Burdens of uncontrolled fire: Pantropical vignettes to achieve visibility

We present evidence from a variety of cases with different degrees of transitions from swidden, and show that losses from

uncontrolled fire were cross-cutting. Losses extend to material and non-material dimensions of smallholder livelihoods, and state support for recovery and resilience was weak to non-existent. Notably, there was a burden manifest in the blame and sanctions that surround fire practice. Such blame emerged discursively and manifested materially in most locations.

The emergent burden of the contemporary fire contexts introduces the highest precarity to households that were subsistence orientated and cash-poor, even when alternative options to fire were available (e.g. in the Malagasy site). Further, restrictions on the autonomy to burn in swidden have the potential to extenuate existing climate-change related vulnerabilities (e.g. in the Philippine site) of smallholder farmers (Brondizio & Moran, 2008; Smith & Dressler, 2020). Extenuating the already considerable vulnerabilities of marginalized communities not only generates injustices but has potential implications for sustainable management of biocultural landscapes in to the future. For example, the degree to which repeated uncontrolled fire results in land abandonment and out-migration to urban areas is not known. Though we know that land abandonment dynamics are related to an expected increase in the frequency of uncontrolled fires (Uriarte et al., 2012). In two study locations (Arapíuns and Paragominas) the risk of uncontrolled fire was a given push factor for at least some of the resident population. Additionally, in the Arapíuns site farmers were aware that the intergenerational use of fire-based agriculture was being truncated as the stigma of fire impacts the younger generations. These dynamics have been observed elsewhere in Latin America (Ponce Calderon et al., 2020) and not only represent a relational burden, but also call in to question the future of swidden farming.

Perverse outcomes of environmentally well-meaning interventions are an additional invisible burden and a real concern. Such back-firing policies can create new social-environmental problems, such as the case in the Malagasy and Philippine sites where international conservation interventions have pursued protected area zoning to safeguard forest land from agriculture and fire. Considerably increasing the pressure on smallholder farmers to adhere to the law, abstain from using fire in forests, and to acquire authorization to burn on fallows. While the sanctions-dominated strategy appears to be associated with low fire prevalence, it has also created additional burdens that are most pronounced for those marginalized community members who have struggled to secure permits to burn, and experienced food security impacts. Meanwhile in the Philippine case, strong sanctions and enforcement against fire resulted in rice failures and the need for calamity rice. Others have shown that sanctions may outperform incentive-based intervention for fire risk reduction, yet highlight the ethical problematic of such an approach (Carmenta et al., 2020). While we capture a number of burdens generated through uncontrolled fires, their impacts on the subjective and relational values such as the place-based attachments, dependencies and identities derived from landscapes is poorly understood and deserves increased recognition through future research efforts (Pascual et al., 2017).

Given the considerable burdens that we identified in each of the case study sites, we argue that recognition of these 'invisible burdens' would constitute a first step toward overcoming common assumptions and narratives circulating among external development and conservation actors about fire-using (or more commonly the derogative term 'slash and burning') smallholders, which include extremes such as labelling Malagasy smallholders

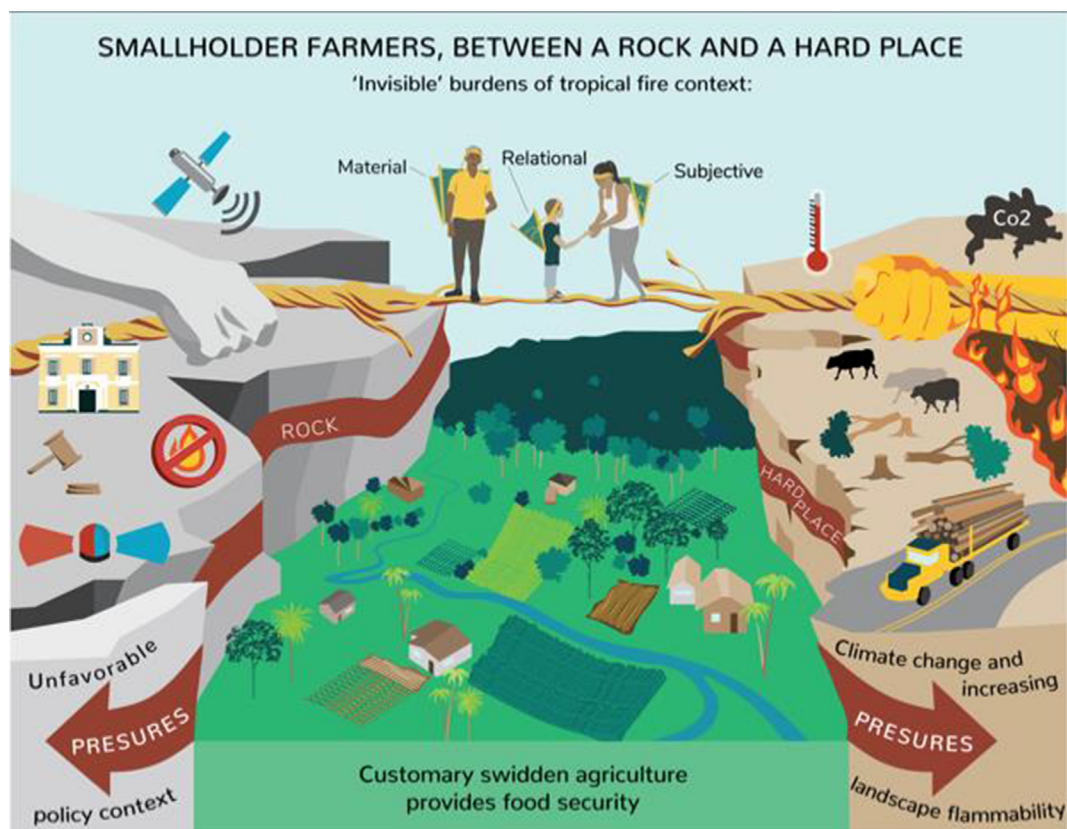


Fig. 1. Tropical smallholders between a rock and a hard place. A conceptual overview of the paper which shows the metaphorical rock and a hard place which smallholders are navigating to access their customary food security through swidden while also bearing the invisible burdens created by the contemporary tropical fire context. The external pressures extenuate smallholder vulnerabilities, and are perpetuated in part due to their invisibility.

'pyromaniacs' (Kull, 2004) while framing traditional farmers as needing to be developed and "include[ed] in our society" (Gonzales, 2019). A better understanding (i.e. recognition) of the diversity of fire types (e.g. intentional, uncontrolled), fire users (e.g. traditional smallholder farmers, small to medium sized investors, colonists), and landscape contexts (e.g. degree of tenure security, soil type) would provide a platform from which to develop targeted fire policy that avoids erroneously shifting the burden of blame (e.g. see Thung, 2018), or creating perverse outcomes for smallholders (e.g. see Carmenta et al., 2018).

5.3. Justice implications of a prevailing oversimplified tropical fire discourse

Fire-based agriculture was a cornerstone of food security in each case study, even in those cases where transitions from fire were more prevalent, which supports other evidence of the centrality of swidden to autonomous food security and the persistence of the rural peasantry (Carmenta et al., 2013; Nazarea et al., 2013; Dressler et al., 2017). While global trends show swidden is declining, it remains important locally (Dressler et al., 2017; Llopis et al., 2019; van Vliet et al., 2012). Place-based fire dependence opposes the mainstream discourse that approaches fire as dispensable (Carmenta et al., 2013). An externally driven anti-fire discourse prevailed in all research sites. The discourse is now part of a larger contemporary process and narrative that discriminates against customary smallholder farmers and their modes of production, culture and lifeways (German, 2010; Nazarea et al., 2013; Shiva, 2008). Contemporary concerns around the aggregate burdens of biodiversity loss, climate change and carbon emissions strengthen and legitimize the narrative. A process which is deeply ironic and troubling considering the juxtaposition of at least four factors. Firstly, the disproportionately small carbon footprints of smallholder farmers practicing swidden on rotational long-fallows compared with global north capitalist consumer societies (e.g. see: The Guardian, 2016), second the increased flammability of tropical landscapes as a result of processes of global environmental change across telecoupled landscapes (Barlow et al., 2018), third, the (unrecognized) significance of the place-based burden of uncontrolled fire to these communities, and finally, the overlooked reality that many smallholder farmers sustain considerable levels of biocultural diversity (Maffi & Woodley, 2012; Martin, McGuire, & Sullivan, 2013). The absence of an environmental justice framing within the discourse enables the creation of an image of smallholder farmers as environmental villains and impostors causing damage in their own lands – rather than recognizing the complexity of agents of fire in contemporary frontiers, or recognizing the biocultural diversity that smallholders' firing and fallowing practices enable (Maffi & Woodley, 2012; Martin et al., 2013; Rai et al., 2019).

By conflating all fire as undesirable and omitting the local utility and cultural practices of intentional smallholders' agricultural fire, the anti-fire position legitimizes prohibitive responses to intentional traditional agricultural fire, curtails state support for traditional agricultural systems and can strengthen state support for industrialized forms of agriculture, or forest protection – the context that we saw in Madagascar and Philippine case studies. Thus the position is biased towards enabling the global land grab which is largely a land grab of the customary lands held by the world's peasant farmers where cultural and biological diversity remains highest (Dell'Angelo, D'Odorico, Rulli, & Marchand, 2017; Escobar, 2011; Fairhead, Leach, & Scoones, 2012). Indeed, such processes of accumulation by dispossession have happened, and are happening, around the world (Burnod, Gingembre, & Andrianirina Ratsialonana, 2013; Hall, Hirsch, & Li, 2011; Martinez-Alier, Temper, Del Bene, & Scheidel, 2016; van Vliet

et al., 2012), and are supported by contemporary authoritarian populist governance (Borras, 2019; Brown, 2013; Gonzales, 2019). These political and economic processes introduce "monocultures of the mind and the land" (Gonzales, 2013; p.96) with potentially negative externalities for people and nature (Kremen & Merenlender, 2018; Rasmussen et al., 2018; van Vliet et al., 2012).

5.4. Can scales of culpability be connected?

Our evidence indicates that farmers linked landscape flammability to both local (e.g. fire management practices) and remote drivers (e.g. climate anomalies), a perspective corroborated across scientific disciplines (see Carmenta et al., 2016; Cochrane & Laurance, 2008; Jolly et al., 2015; Silvestrini et al., 2011). However, in all sites policy responses tended to exclusively target the local fire management practices of landholders, rather than address the broader political economic context which contributes fundamentally to landscape flammability (Barlow et al., 2018; Sorrensen, 2009). Nevertheless, smallholder farmers themselves regarded local actions as the needed and necessary responses that could decrease the prevalence of uncontrolled fire – perhaps reflecting the absence of the state for fire control: none of the sites received consistent state-support for agricultural fire-management, fire-fighting or for recuperation from fire damages.

We highlight an ethical issue in which mitigating risks created partly by external factors has fallen to local land managers. Such problems are manifest in other environmental justice spaces, including within the climate justice movement where questions of responsibility, blame and the disproportionate impacts on particular groups of people creates ethical and governance dilemmas (Boillat et al., 2018; Corbera et al., 2019; Fischer et al., 2012). Further, these interactions across scales combined with the attributes of fire (e.g. to move after being set giving anonymity to fire-users) make it difficult to define attribution and apportion culpability (Gaveau et al., 2017; Kull, 2004). In each site, perceptions were that both escaping fires from neighbouring farmers, and fires coming from distant unknown places were leading to uncontrolled fires. Geospatial analysis supports local narratives and indicates that extensive uncontrolled fire events are associated with burning by multiple actors and fires moving across landscapes driven by factors across scales (Aragão et al., 2018; Cattau et al., 2016; Gaveau et al., 2017; Jolly et al., 2015). The situation highlights both an ethical issue in which the distributional burden of fire management is born most heavily by the most marginalized groups, and a governance challenge – namely, how to define just governance responses to transboundary environmental problems (Zeitoun, 2013). We argue that without recognizing the diverse local and remote factors contributing to landscape flammability, identifying the interventions that can sustainably and equitably reduce fire contagion will remain unfeasible.

5.5. Options for more just alternatives

Prohibiting fire alongside agricultural transitions including agroforestry and intensification and protecting land from people are offered as solutions to reduce the frequency of uncontrolled fires (Buizer & Kurz, 2016; Laney & Turner, 2015). However, our findings have shown that the prohibitive approach to agricultural fire is not consistently reducing fire risk, and can generate perverse outcomes. Further, if prohibitive fire policy is pursued without appropriate alternatives it can compromise conservation efforts, local food security and generate unacceptable burdens on smallholders, raising issues of environmental (in)justice in swidden landscapes (Carmenta et al., 2018; Ickowitz, Powell, Rowland, Jones, & Sunderland, 2019). The case studies show that alternatives

to fire-based farming and the burdens of uncontrolled fire can co-occur. For example, in Paragominas, expanding soy production and intensified pastures coexist with a high frequency of uncontrolled fires. In Madagascar, cash crops were associated with less risk of uncontrolled fire but their expansion has involved other burdens, particularly for the most marginalized who cannot afford cash-crop start-up costs. Further, transitions to agroforestry seem unlikely when the risk of uncontrolled fire is high (e.g. in Paragominas and Arapíuns sites) since farmers in the communities consider fire-risk jeopardizes their investments, a finding consistent with elsewhere (e.g. Cammelli, Garrett, Barlow, & Parry, 2020).

Introducing intensification as a fire control mechanism is fraught with biocultural dilemmas and ignores the fact that ecological and cultural diversity co-occur, and are apparently mutually supportive (Maffi & Woodley, 2012; Martin et al., 2013). Further, the relationship between agricultural intensification and human well-being (subjective, objective and relational) is not well understood but appears to be negative (Rasmussen et al., 2018). Others have suggested that a “diversity-friendly justice [...] can also be a biodiversity-friendly justice” (Martin et al., 2013). An important step forward is to avoid the general assumption that prohibiting fire, intensifying agriculture and introducing environment-related interventions automatically lead to win-win scenarios and instead start by anticipating trade-offs. Mapping these from the outset would reveal potential losers and winners from natures contributions to people, enabling policy decisions to generate more equitable outcomes (Ellis, Pascual, & Mertz, 2019; ESPA, 2018).

Our results show that smallholders use a number of management practices to prevent intentional fires for agriculture (and land management) spreading beyond control. Perhaps these provide starting points to understanding smallholder methods for fire control, and future research could identify what additions and adaptations are deemed necessary given the altered ecologies of many tropical forest landscapes. Equitable responses to fire spread must be sensitive to the distinctions between fire types and incentives for fire use and the distinct traditional agricultural practices that engage fire, as well as cognizant of the local burden that new relationships with fire (i.e. through modified ecologies, new stakeholders and climate contexts) introduce (Nóbrega Spínola et al., 2020). By understanding the local burdens created through exposure to new contexts in which uncontrolled fires are more prevalent, we can begin to co-design responses that are targeted at restoring the losses and alleviating the material and non-material burdens of more flammable landscapes. Processes of co-creation can serve to redistribute power, engage plural values and diverse perceptions and deliver to local needs (Wyborn et al., 2019). Environmental justice framings have shown that assumptions about pathways to more equitable and sustainable futures are divergent across actors (Martin et al., 2013) and that solutions to environmental problems require negotiation in plural intercultural appraisals (Mistry, Schmidt, Eloy, & Bilbao, 2019; Sletto & Rodriguez, 2013). Justice is a contested notion in biodiversity conservation and there are different ways of knowing and valuing nature which are not only material, neither purely economic, but deserve and demand recognition (Martin et al., 2013; Pascual et al., 2017).

Recognizing the multiple (i.e. subjective, objective, relational) place-based burdens experienced by smallholder farmers from uncontrolled fire events is an important step towards justly responding, and building resilience to the risk of uncontrolled fire. By understanding the place-based losses resulting from transitions towards increased landscape flammability, it becomes possible to work towards strategies for regeneration, response and resilience that are better placed to align with local aspirations, knowledge and needs; regenerate place-based attachments and stewardship, and avoid shifting the final burden of risk reduction on to socio-economically and politically marginalized and vulnerable people (Chan, Gould, & Pascual, 2018; Kohler & Brondizio, 2017).

6. Conclusions

To conclude we propose that contemporary traditional smallholders are between a rock and a hard place. Smallholders must practice burning to achieve food security, yet they must do so in an unfavourable policy context (dominated by prohibition and stigma), and within the context of ever riskier conditions generated by global environmental change. Smallholder farmers are subject to scrutiny and surveillance partly due to the aggregate burdens that uncontrolled fires represent to the global, non-local community and yet the place-based burden of uncontrolled fire is largely invisible. The simplifications in the discourse fail to recognize the multiple loci of culpability of flammability. Meanwhile smallholders bear the burden of uncontrolled fire events, and receive little support for site-level fire control. Solutions such as protected areas, fire prohibition and agricultural intensification have served to magnify inequalities rather than remedy them. Bringing awareness to the place-based impacts of increasing flammability, prohibitive policy and uncontrolled fires must be done within the context of recognizing the role of intentional fire in smallholder traditional agriculture and co-creating fire-resilient practices. Transformations towards reducing the risks of uncontrolled fires might be better supported by a discourse embedded in the environmental justice dimensions of the place-based experience of flammable landscapes.

CRedit authorship contribution statement

Rachel Carmenta: Conceptualization, Writing - original draft, Visualization, Data curation, Methodology, Investigation, Writing - review & editing, Funding acquisition. **Federico Cammelli:** Data curation, Methodology, Investigation, Writing - review & editing, Funding acquisition. **Wolfram Dressler:** Data curation, Methodology, Investigation, Writing - review & editing, Funding acquisition. **Camila Verbicaro:** Investigation, Data curation, Writing - review & editing. **Julie Zähringer:** Data curation, Methodology, Investigation, Writing - review & editing, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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